Chem 108
Introductory Chemistry

Dr. Ron Rusay

CONNECTIONS: Chemistry ⇆ STEM ⇆ Applications

STEM

S Science
T Technology
E Engineering
M Mathematics

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http://chemconnections.org/general/chem108/108%20Intro.1A%202017f.htm

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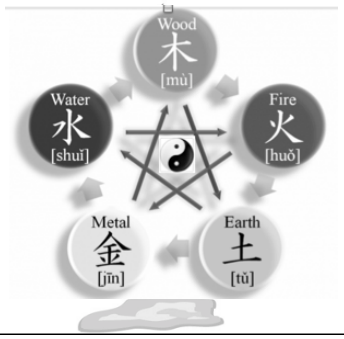
What is the stuff around us? How do things work?
Ancient Questions: in Greece, China, Arabia, Persia



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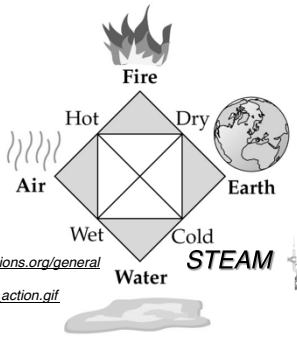

STEAM

http://chemconnections.org/general/chem106/Steam_engine_in_action.gif

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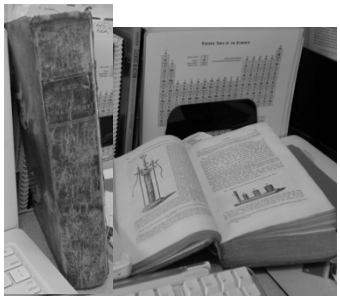


RESULTS: Protocols, Explanations, Comparisons, Predictions & Tangible Products: "Ponderables versus Imponderables" (terms used circa 1830)
Additionally: MANY MANY VOCABULARIES in many languages

CHEM 108: Science, Chemistry, Mathematics, & Questions about the World Around Us

- What is Science?…. What is Chemistry?
- VOCABULARY: Key Terms → COMMUNICATING
- Comparisons and Conversions :
  Ratios, Percent, Density, Moles, Masses
- Mathematics / Arithmetic:
  Adding, Subtracting, Multiplying, Dividing, Powers of Ten, Scientific Notation
- Measurement & Units: (metric)
- Matter & Energy : Classification & Properties
- Periodic Table

Information & Knowledge

How are they acquired?
Hearing, Seeing (Viewing/Reading), Doing

Which works best for you?
It depends on our individual traits & skills

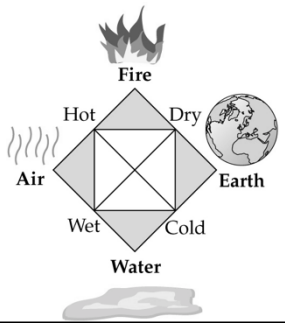
How can these be discovered?
Various surveys can be used.

Your first assignment ("Metacognition"):
http://chemconnections.org/general/chem108/learning.html
Complete a Learning Style Survey.
Apply the results.

Click Image

What is the stuff in the world around us?
How does stuff work?

Ancient Questions: in Greece, China, Egypt & Arabia, Persia



Does the sun "rise" in the east?

Observations: Perception

STEM relies on observations.

- *Can more than one observation be correct?*
- *What do you see?*

Observations: Perception

STEM relies on observations: SEEING

http://video.pbs.org/video/2365563172/

Seeing & Visibility

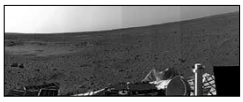
TED (Technology/Education/Design) Talk

https://www.youtube.com/watch?v=8EUy_82lChY
~9 minutes

Awareness & "Change Blindness"

https://www.youtube.com/watch?v=VkrrVozZR2c
~4 minutes

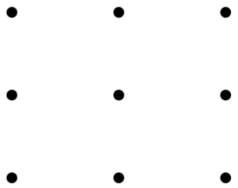
What might this be?



http://mars.nasa.gov/
Why is this important?
Would you colonize Mars?
200,000 people applied!... for a one-way trip?

Problem Solving

Connect all of the dots with four straight lines without taking a pen or pencil from the surface and passing through each point only once.



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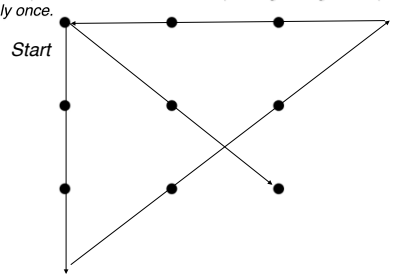
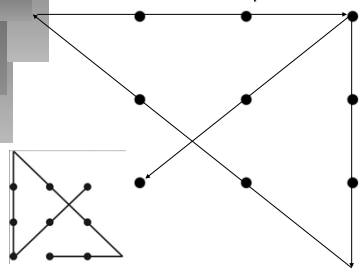
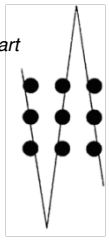


Problem Solving

Can there be more than one solution for the same problem?

Of Course!





Problem Solving

An arborist is asked to plan an orchard that has 10 trees arranged in 5 rows having 4 trees in each row.

•Find a pattern that satisfies the plan.

Click for the answer

Problem Solving

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Click for the answer

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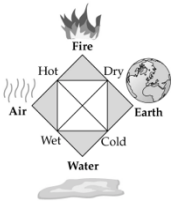


Aristarchus
~ 270 B.C.E.

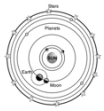
Does the sun "rise" in the east?

Two plausible possibilities.

(Geo-centric model)
Sun moves around the earth.

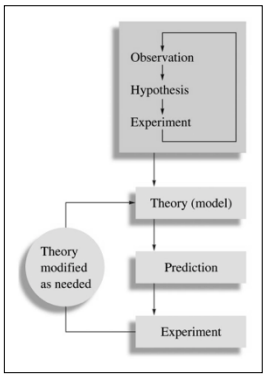
(Helio-centric model)
Earth rotates and moves around the sun.

Cleanthes & Stoics
~ 270 B.C.E.



The Scientific Method

- STEM discoveries are driven by observing, asking questions, & making predictions, but where does it end and philosophy & speculation begin?
- The Scientific Method is a way to predict outcomes and develop logical theories, but it is not foolproof!



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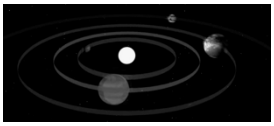


https://www.youtube.com/watch?v=4yzraWw8mrc

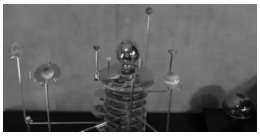
Does the sun "rise" in the east?

Geo-centric
Until the 16th century: Copernicus / Galileo

Helio-centric
Sometime after 1512.

Does the earth rotate clockwise or counter -clockwise?

Question

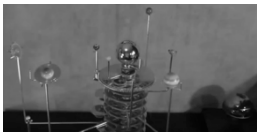


https://www.youtube.com/watch?v=HnASxhZyuIU

Does the sun rise in the east and does the earth rotate clockwise or counter -clockwise?

A) Yes, Clockwise
B) Yes, Counter-clockwise
C) No, Clockwise
D) No, Counter-clockwise

Question



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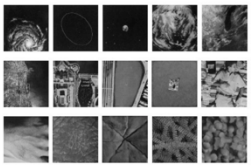
Helio-centric
Sometime after 1512.

Some Possible Steps in the Scientific Method

1. Observations
   - qualitative (generalities)
   - quantitative (numbers)
2. Formulating hypotheses
   - possible explanation for the observation
3. Gathering information & Performing experiments
   - gather new information to test whether the hypothesis is valid

Observations
Measurements & Relative Scale

- Macroscopic vs. Microscopic
- Charles & Ray Eames / IBM financed video:



http://chemconnections.org/general/movies/Powers Of Ten (Charles & Ray Eames) 1.mp4

https://www.youtube.com/watch?v=0fKBhvDjuy0

Powers of Ten (Images) http://www.wordwizz.com/imagendx.htm

http://www.eamesoffice.com/

Question

Measurements & Relative Scale

- *Macroscopic vs. Microscopic*
- *Charles & Ray Eames*

- *TRUE (A) / FALSE (B)*

Macroscopic stuff is visible to the naked eye. Microscopic objects require magnification.

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Powers of Ten: Scale

10^n — exponent; base number

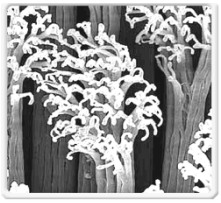
Powers of 10

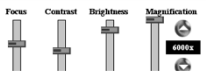
Exponential Number	Ordinary Number
$1 \times 10^6 = 10 \times 10 \times 10 \times 10 \times 10 \times 10$	1,000,000
$1 \times 10^3 = 10 \times 10 \times 10$	1,000
$1 \times 10^2 = 10 \times 10$	100
$1 \times 10^1 = 10$	10
$1 \times 10^0 = 1$	1
$1 \times 10^{-1} = \frac{1}{10}$	0.1
$1 \times 10^{-2} = \frac{1}{10} \times \frac{1}{10}$	0.01
$1 \times 10^{-3} = \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10}$	0.001
$1 \times 10^{-6} = \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10}$	0.000 001

Microscopic Gecko's Toe and Setae

6,000x (6 x 10^3)

Magnification using Atomic Force Microscopy (AFM)





Full et. al., Nature (2000)
5,000 setae / mm²
600x frictional force; 10^{-7} Newtons per seta (0.0000001)

Geim, Nature Materials (2003)
Glue-free Adhesive
100 x 10^6 hairs/cm² (100,000,000)
Yurdumakan, Chem Comm (2005)
200X Gecko's Force

http://micro.magnet.fsu.edu/primer/java/electronmicroscopy/magnify1/index.html

Biomimetics and evolution

https://www.youtube.com/watch?v=9ZJYbcG0Ts0

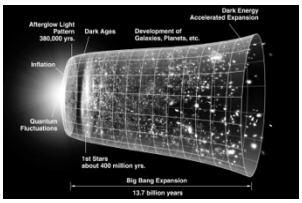
Science 345, 1448 (2014)

Biomimetics and evolution

http://www.darpa.mil/program/z-man

Macroscopic

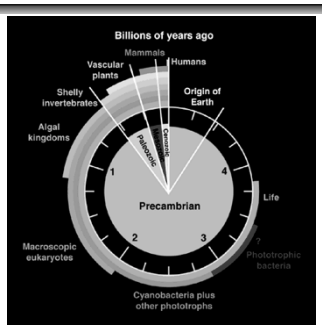
http://www.space.com/24309-shape-of-the-universe.html



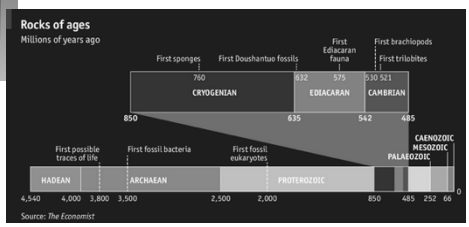
How does the age of the universe compare to the age of the earth? $\frac{13{,}700{,}000{,}000 \text{ years}}{4{,}540{,}000{,}000 \text{ years}} = 3\text{ x}$

The earth is considered to be 4,540,000,000 years old.

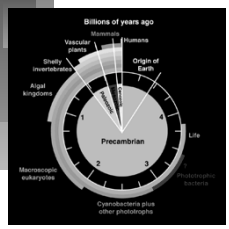
Simple Graphic Comparisons



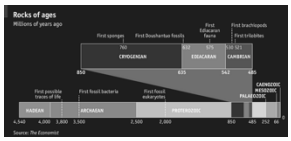
Simple Graphic Comparisons



Simple Graphic Comparison(s)



The earth is 4.54 billion years old and some humans' average lifespan is estimated to be ~80 years.

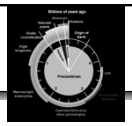


How does our lifespan compare to the age of the earth?

$\frac{4{,}540{,}000{,}000 \text{ years}}{80 \text{ years}} = 56{,}750{,}000\text{x}$

1/56,750,000 = 0.0000000176

QUESTION



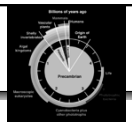
The earth is 4.54 billion years old and assume that our average lifespan will be 80 years. If the total age of the earth is represented by the face of a clock, how much time will 80 years be represented on the clock?

A) 0.001520 seconds ***B) 0.00076 seconds***

C) 0.0008 seconds ***D) 7,600,000 seconds***

E) 15,200,000,000 seconds

Answer



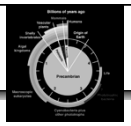
Assume that the earth is 4.54 billion years old and that your average lifespan will be 80 years. If the total age of the earth is represented by the face of a clock, how much time will 80 years be represented on the clock?

$\frac{80 \text{ years}}{4{,}540{,}000 \text{ years}} = \frac{?\text{ hrs}}{12 \text{ hrs}}$

$\frac{80 \text{ years x } 12 \text{ hrs}}{4{,}540{,}000 \text{ years}} = ?\text{ hrs}$

$= 0.000000211 \text{ hrs} \rightarrow ?\text{ sec}$

Answer



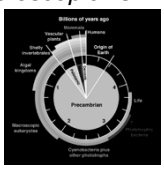
Assume that the earth is 4.54 billion years old and that your average lifespan will be 80 years. If the total age of the earth is represented by the face of a clock, how much time will 80 years be represented on the clock?

A) 0.001520 seconds (1520 microseconds)
B) 0.00076 seconds (0.76 milliseconds)
C) 0.0008 seconds (8 x 10^{-4} seconds)
D) 7,600,000 seconds (7.6 megaseconds)
E) 15,200,000,000 seconds (15.2 gigaseconds)

0.000000211 hr x 60 min/hr x 60 sec/min = ? sec

Scale & Relative Sizes

- *Macroscopic vs. Microscopic*



How would you compare the age of Confucius (Master Kong, 孔夫子) born 551 BC, if he were alive today, to the age of the earth?…How would the age of mankind compare to the age of all living things?.. ..the age of industrialized mankind to the age of mankind?

Scale & Relative Sizes

- *Macroscopic vs. Microscopic*

How would you compare the age of Confucius (Master Kong, 孔夫子) born 551 BC, if he were alive today (551 yrs + 2016 yrs = 2567 yrs), to the age of the earth?…

$$\frac{4{,}540{,}000{,}000 \text{ years}}{2567 \text{ years}} = 1{,}768{,}000 \text{ x}$$

1/1,768,000 = 0.000000566

How would the age of mankind compare to the age of all living things?.. ..

$$\frac{3{,}800{,}000{,}000 \text{ years}}{200{,}000 \text{ years}} = 19{,}000 \text{ x}$$

the age of industrialized mankind to the age of mankind?

$$\frac{200{,}000 \text{ years}}{200 \text{ years}} = 1{,}000 \text{ x}$$

Modern Science & Chemistry

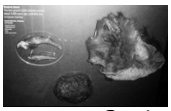
SCIENCE

Ancient Sloth Dung Excites Scientists

- *Would this excite you enough to pursue a career in science & chemistry?*
- *What would be the title of the scientist's PhD thesis and what does dating have to do with it?*

"People called my Ph.D thesis my 'Ph.D feces,'" says Hendrik N. Polnar, an American biologist working at the Max-Planck-Institute for Evolutionary Biology in Munich.

How do we know how old things are ?… like sloth dung



Carbon Dating

Radiocarbon dating allows determining the age of biological artifacts like dung up to about 40,000 years old. This method provides an indirect measurement of age.

- *How do we determine our own age?*
- *Can this work for anyone or any animal that ever lived?*

Representations of Measurements:

An example of a relative comparison using length to represent time

- *TIME: 38,000 year old (dung) vs. 20 year old student*

38,000 yrs / 20 yrs = 1900 x

- *LENGTH:*
  - *Use lines to represent the respective ages that can be easily drawn on the classroom's blackboard.*
  - *Let 1 inch equal some period of time: 1 yr, 5 yr, 10yr, 100yr, 1000yr. (Select an appropriate one.)*
  - *38,000 year old (dung) vs. 20 year old student*

Representations of Measurements

An example of a relative comparison using length to represent time

- *TIME: LENGTH; 38,000 year old (dung) vs. 20 year old student*
  - *1 in= 1 yr: dung = 38,000 in (> 1/2 mile) - student = 20 in*
  - *1 in= 5 yr: dung = 7,600 in (> 2 football fields) - student = 4 in*
  - *1 in= 10 yr: dung = 3,800 in (> 100 yds) - student = 2 in*
  - *1 in= 100 yr: dung = 380 in (31.6 feet) - student = 0.2 in*
  - *1 in= 1000 yr: dung = 38 in (3.16 feet) - student = 0.02 in*

Match the years in the second column with choices from the first column

A. Age of the earth	_____85 years
B. Average lifespan of a woman in US	_____195,000,000 years
C. Extinction of BIG dinosaurs (Years ago)	_____ 58 years
D. Alchemy (Years ago)	_____ 13,700,000,000 yrs.
E. Average lifespan of a man in Russia	_____ 2500 yrs.
F. Ancient science (Years ago)	_____ 3,800,000,000 yrs.
G. Age of chemistry	_____ 400 yrs.
H. Dr. R's age	_____ 200-300 yrs.
I. Age of the universe	_____ 1000 yrs.
J. Extinction of LITTLE dinosaurs (Years ago)	_____ 4,540,000,000 yrs.
K. Age of Modern Science	_____ None of the choices
L. First life on earth	_____ 65,000,000 yrs.

Match the years in the second column with choices from the first column

A. Age of the earth	__B__85 years *or H?*
B. Average lifespan of a woman in US	__C__195,000,000 years
C. Extinction of BIG dinosaurs (Years ago)	__E__ 58 years *or H?*
D. Alchemy (Years ago)	__I__ 13,700,000,000 yrs.
E. Average lifespan of a man in Russia	__F__ 2500 yrs.
F. Ancient science (Years ago)	__L__ 3,800,000,000 yrs.
G. Age of chemistry	__K__ 400 yrs.
H. Dr. R's age	__G__ 200-300 yrs.
I. Age of the universe	__D__ 1000 yrs.
J. Extinction of LITTLE dinosaurs (Years ago)	__A__ 4,540,000,000 yrs.
K. Age of Modern Science	__H?__ None of the choices
L. First life on earth	__J__ 65,000,000 yrs.